Exploring Machine Autonomy and Provenance Data in Coffee Consumption: A Field Study of Bitbarista

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Technologies such as distributed ledgers and smart contracts are enabling the emergence of new autonomous systems, and providing enhanced systems to track the provenance of goods. A growing body of work in HCI is exploring the novel challenges of these systems, but there has been little attention paid to their impact on everyday activities. This paper presents a study carried out in 3 office environments for a 1-month period, which explored the impact of an autonomous coffee machine on the everyday activity of coffee consumption. The Bitbarista mediates coffee consumption through autonomous processes, presenting provenance data at the time of purchase while attempting to reduce intermediaries in the coffee trade. Through the report of interactions with and around the Bitbarista, we explore its implications for everyday life, and wider social structures and values. We conclude by offering recommendations for the design of community shared autonomous systems.

CCS Concepts: • **Human-centered computing → Empirical studies in interaction design**;

Additional Key Words and Phrases: Blockchain, Distributed ledger technologies, Distributed autonomous systems, Heteromation, Provenance, Supply chains.

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1 INTRODUCTION

From robot vacuum cleaners, to customer service messaging bots, autonomous machines play an increasing role in our everyday lives. The advent of cryptocurrencies, distributed ledgers technologies, and particularly "smart contracts" [28, 39] has provided the basis for a new level of machine autonomy, one entrusted with executive decisions for financial transactions, either as a mediator between different parties, or by operating as a self-owned entity in its own right. While there is growing interest and awareness of the potential human and social implications of these technologies, there has been limited investigation into their effect on human experience, or their broader social impact.

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Fig. 1. Bitbarista ready to serve a coffee

In addition to significant work addressing technical aspects of distributed ledgers e.g. [41, 43], previous work within HCI has focussed on defining and describing key attributes of these technologies in order to understand their potential purpose and impact in various sectors [13, 14], exploring interactions with cryptocurrencies and the potential socio-economic impact [15, 20, 35, 36], and exploring these technologies through workshop activities to develop innovative products and services [25]. This work has provided necessary intellectual building blocks as these technologies and their potential applications are abstract and difficult to comprehend. Projects within HCI and design have also resulted in numerous speculative works, provocations that illustrate potential futures for these technologies [8, 9, 11, 22, 24, 32, 37]. However, their speculative focus compromises an understanding of the nuts and bolts of designing such systems. This paper seeks to go beyond existing conceptual and speculative work in this space, to explore the potential social impact and design implications of these new technologies through the empirical study of everyday interactions around an actual implementation.

This paper presents an in-depth study of the Bitbarista, an autonomous coffee machine that mediates coffee consumption through autonomous processes (see Figure 1). The simple act of purchasing coffee provided an ideal focus for such explorations for two reasons. Firstly, the final product of hot coffee in a cup is already familiarly mediated by automated dispensing machines. The construction of Bitbarista leveraged existing processes of automation, enabling us to achieve a high level of finish and convincing operation produced by the build quality of the commercial coffee machine on which the Bitbarista is based. Secondly, it introduced the potential to explore one of the most significant application areas of blockchain systems: certainty around provenance and supply chain data, where such trusted systems are seen to provide value. Information regarding

provenance is already known to add value to coffee products [23] and they are often accompanied by certifications regarding production methods and their social and environmental impact, for example Fairtrade or the Soil Association. The Bitbarista's design focusses on the consumer end of the supply chain with the aim of exploring the customer experience of interactions with coffee provenance data.

This study views machine autonomy through the everyday act of coffee consumption within the office. Office spaces were chosen as an ideal environment because we wanted to embed the coffee machine in a site that would be rich in existing social relations and practices around coffee drinking. Within an office, the act of coffee drinking already has an established set of practices, whilst coffee making provides a number of practical tasks that regularly need to be achieved. The offices provided safe, non-public spaces that ensured multiple, repeat customers with pre-existing, convivial relationships. This enabled us to explore the impact of the machine on everyday individual practices and also existing social relationships. For the study we located the Bitbarista in 3 different offices for a period of 1 month in each. This length of time meant that participants had numerous transactions with the machine and could experience and respond to Bitbarista's various functions, and develop their own understanding and responses. This enabled us to learn about the behaviour and attitudes that unfolded over time as part of everyday life.

This paper begins by grounding the work in previous literature exploring similar autonomous systems that focus on trade and cryptocurrency, and projects that have explored the value of provenance data in consumption practices. We then describe the implementation of the Bitbarista and the interactions it affords. We present the field work in the form of short exemplary descriptions of participant interactions with and around the machine. These are used to highlight potential implications for designing such systems, and suggest considerations and potential alternative approaches that may better fit with everyday lives. The findings focus on behaviours around the Bitbarista, and provide us with a glimpse into our autonomous futures, enabling us to consider implications for other such autonomous systems.

2 CONTEXT AND RELATED WORK

2.1 Autonomous Systems and Smart Contracts

Blockchains and smart contracts present an additional layer of machine autonomy, distinct from that which has been associated with robotics and AI, where machines can perform physical and cognitive tasks independently. For example, in autonomous vehicles "autonomy" refers to the system's ability to perform driving tasks, that are both cognitive and physical, without human involvement (e.g. Rodel et al. [34]. Similarly, Nowacka et al. investigate human interactions with tangible autonomous interfaces through responses to an autonomous helium balloon that documents activity in interior spaces [29, 30]. Blockchains, or more generally distributed ledgers technologies (DLTs), provide an immutable, tamper-proof record of transactions that can facilitate trustless entities in making automatic exchanges that include a monetary value. Nakamotos's Bitcoin protocol [26] is the first example of a blockchain, although in summer 2017, Elsden et al. surveyed over 200 blockchains in different domains [13]. Of particular interest is the ability of blockchains to run smart contracts. Smart contracts are self-executing protocols whose integrity is assured by the blockchain's replication and synchronisation of files. Once distributed, these protocols cannot be modified and become "contracts" [39]. Without central management, their design underpins a new notion of autonomous, algorithmically driven systems [5]. Smart contracts can make payments programmatically, automating negotiations, while reducing friction and possibly intermediaries, whilst the blockchain protocols guarantee consistency of transactions, thus providing trust between stakeholders. Lustig has coined this "algorithmic authority", describing it as "the trust in algorithms

to direct human action and to verify information, in place of trusting or preferring human authority". This process of autonomous governance offers the potential for financial independence of machines, rather than the physical and cognitive independence explored by Nowacka et al. [30].

This has led to speculation around systems that go beyond interactions with individual autonomous things and support the interactions of entire organisations, producing the potential for so called "distributed autonomous organisations" (DAOs). These systems are not only algorithmically managed but are self-owned. They are considered to provide more transparency, objectivity and potentially to challenge current models of ownership and power [42]. The potential for distributed autonomous organisations has been explored in both HCI [28] and design [7]. Tokenisation serves as the basis for these systems where data, information, an asset, time, or anything that could have value in a particular context can be exchanged with a token. This token can be represented as currency, for example Bitcoin. Accounts or "wallets" used to carry out such cryptocurrency payments do not require validation by a human identity, which means these wallets can be held by non-human entities, and this enables computational systems to trade independently. DAOs use tokens, respective currency values, and cryptocurrency wallets to pay for services and guarantee the performance of actions that are important to the system. Most often this is used in a process of heteromation, where the system is acting as employer and human actions are subordinate [12]. For example, Amazon's Mechanical Turk, whilst not a DAO, facilitates developers in sourcing humans to perform physical or intellectual tasks that would be difficult for machines as part of digital applications. Similarly, DAO's use micropayments to incentivise humans to perform tasks and actions, often physical ones.

2.1.1 Speculations of Distributed Autonomous Organisations. The new autonomy afforded by DLTs and smart contracts, and their potential in many aspects of society, from small business units to government systems, has inspired both radical startups (e.g. BitNation) and a broad body of speculative design work. A number of examples, notably in digital artworks, explore the potential future of DAOs, and the nature of this financial autonomy [8, 9, 24, 37]. One such artwork "Plantoids" [9] requires the viewing public to make donations of Bitcoins in exchange for the experience and these Bitcoins are then used to propagate more Plantoids. Plantoids design evolves through algorithms that respond to the popularity of existing Plantoids, and the system uses the donated Bitcoins to hire artists to build the new designs. Thus, the exchange of viewing art for Bitcoin is intrinsic both to the experience and to the continuation of the project. In a similar vein "FinBook" [8] makes this commodification of public appreciation more explicit. Here each article in the book "Artists Re: thinking the Blockchain" [7] has been assigned a "Finbot" which can trade donations made by participants on the stock market. The idea is that readers donate currency based on their appreciation of the article, much like the audiences of Plantoids. The Finbots then invest these funds in stocks, on the basis of the political, ethical and cultural values of the author of the article, with the intention of reflecting the author's values.

Despite their creativity and ambitions, from descriptions of these systems it is often difficult to separate fact from fiction, and without study it is challenging to understand their wider social implications. There is an assumption in these projects that micropayments are an effective way of mediating the interactions and values of the people that engage with them, and that the use of cryptocurrencies and smart contracts is a way to guarantee trust. However, other work suggests that this broadly libertarian perspective may be problematic. Exploring the subject of monetisation of cultural forms, Philippa Thornton's "Poem.py" produces a receipt for poems based on the current cost in the Google marketplace of the words contained in the poem. In doing so, it exposes the commodification of language by Google [40]. By stripping down poems to their constituent parts and equating them directly with a cost in sterling, it reveals the reductive nature of the Google

marketplace for word use. More explicitly suggestive of the potential problem of commodification is an analysis which compares the process of bartering with that of paying with money. Carroll and Bellotti [6] discuss how the involvement of money in exchange can contribute to the reduction of the social ties and bonds that may form in the more complex and interwoven process of bartering. Our empirical study of Bitbarista was designed to explore responses to the commodification of maintenance tasks, where the Bitbarista requests for help from customers in return for micropayments. The intention was to examine both individual participant responses to this process, and their perceptions of potential wider social implications.

2.2 Provenance and Distributed Ledgers

Recent ethical models of trade have increased awareness around the provenance of products, motivating consumers to question conditions of production. In horticulture "provenance" refers specifically to the place in which a plant is grown as a crop, and which may not be its native environment [21] [4]. However, in recent years, special attention has been paid to the practices around the site of production, in particular: the conditions of growth (e.g. fertilisers) and crop protection (e.g. pesticides) that may affect the quality of produce, the long-term health of the environment, and the quality of life for people involved in the work of cultivation. Labels such as Rainforest Alliance, Fairtrade and models of Direct Trade, which have been inaugurated or popularised in the coffee industry, have brought new awareness of the processes, practices and conditions of food production. Loureiro and Lotade [23] conducted an extensive survey that revealed that customers to supermarkets in the US will pay higher premiums for produce labelled with specific information regarding provenance, than for generic labelling such as "organic". This work and others [17, 27] suggests that provenance is given consideration when assessing the value of a product. Efforts have been made in HCI to explore the value of augmenting objects with information regarding their provenance, for example, by tagging physical objects with digital data regarding the object's history [3], [10], revealing previous ownership of second hand goods [1], and presenting the lifecycle of products to consumers [2], and these have also found this of value to participants.

The actual provenance of products is often hard to track, but potential solutions have arisen from implementations of DLTs and smart contracts together with the use of tracking sensors. These technologies form the backbone of emergent autonomous systems within applications involving governance and justice. Characterised by Swan as "Blockchain 3.0" [38], they are seen to have value in tracking provenance and ownership of a vast range of products. Blockchains in particular have supported a number of services aimed at increasing automation of trade transactions (e.g. implemented by IBM), reliably revealing steps in the distribution of goods, and substantiating claims around provenance. Everledger and Provenance are two early commercial blockchain companies. Everledger (everledger.io) employs technology to identify diamonds by their unique optical structure and uses this together with blockchain technology to certify origin and previous ownership. The intention here is to warrant the value of particular diamonds, and also to reduce the poor social practices and the fraud that is currently endemic in this trade. Provenance (provenance.org) tracks a range of goods and relies on IoT technologies to provide data on both their place of origin and the conditions of their transit. Underpinned by a tamper-proof ledger system, they propose to provide the means of ensuring validity of data regarding the origin of products and their journey through the supply chain, authenticating transactions across disparate institutions and economies, in order to maintain the value of ethical production practices through to the end-consumer [19]. Whilst these systems are not designed specifically to produce autonomy, they suggest an application of blockchain technologies in which value is added by the gathering and presentation of data on provenance. These systems have not yet been tested as part of everyday life, and customer responses to the front-end experience is yet to be explored. The design of the Bitbarista was intended to

present an experience that might be underpinned by such a system, to examine how customers might respond to the presentation of this data as part of the process of coffee consumption.

2.3 Bitbarista: heteromation, provenance and Bitcoin

Companies like Everledger and Provenance are developing back-end solutions using DLT's to track provenance. In contrast, the Bitbarista presents an everyday front-end experience with provenance data that has purportedly been collected and processed by an autonomous organisation. The Bitbarista appears to collect and analyse the data on coffee production, and co-opts people into its system using heteromation when it requires the performance of maintenance tasks.

In this study we explore machine autonomy primarily through the process of heteromation where the Bitbarista pays customers for maintenance tasks. Autonomous governance is suggested through a number of its processes: filtering provenance data from which it presents top-ranked matches of particular coffees, moderating customer voting and ordering new supplies of coffee based on votes. Customers responses to provenance data are explored primarily through the system of voting for future coffee supplies. In the Bitbarista design the concepts of autonomy and provenance are not closely integrated and could have been studied separately. However, we have chosen to explore the concepts together as part of a holistic customer experience where they mutually shape each other. Whilst in practice the Bitbarista does not record or deliver provenance data using Blockchain technologies, the use of Bitcoin as a currency was intended to suggest this possibility. Bitcoin also provides the machine with the means to independently make and receive payments, and furthermore indicates the possibility that Bitbarista could be underpinned by a universal currency enabling direct trade between consumers and growers. Whilst the back-end for this trading was not implemented, the use of Bitcoin hints at a potential future in which supply chains operate in radically different ways. In the following section we describe the Bitbarista in more detail.

3 IMPLEMENTATION

The Bitbarista was intended to be taken as a real, working product by the participants in this study, rather than a stepping stone to a commercial product, or a design speculation. As such the Bitbarista is closely aligned with the concept of a "research product", as a technological artefact produced by a research project that presents alternative possible futures through its use [31]. The first phase of building the Bitbarista was completed in 2016, which was trialled in a study of initial perceptions after a one-off use, supervised by a researcher. In this first phase, the Bitbarista was primarily design-led, and was intended to result in a product which enabled participants to have a meaningful interaction with the autonomous system exploring coffee provenance in this context. The study revealed a positive response towards the direct connection with coffee growers engendered by Bitbarista, and this is reported together with the design rationale of the Bitbarista in Pschetz et al. 2017 [33]. At this stage while most of the decisions regarding design concepts had been made, the Bitbarista was not sufficiently developed to operate independently in a longer-term study, a defining quality of Odom and colleagues' research products. The autonomous behaviours of the machine were subsequently developed and made to work reliably, alongside various interventions of the research team. As we were concerned with the empirical study of use rather than technical challenges, developing back-end solutions would not have been resource effective. The development of the front-end autonomous features resulted in a more robust version of the machine that could work independently and enabled the required study. In the following sections we reiterate the design described in the 2017 paper for clarity, together with these new developments.

The Bitbarista consists of a home coffee machine that has been augmented with a Raspberry Pi, touch screen and camera. It is connected to the internet and has its own Bitcoin wallet (see Figure 2). It serves coffee and a vote for the future coffee supply in exchange for small Bitcoin

contributions. Bitcoin was chosen as a currency because blockchain technologies support trading in cryptocurrencies, and cryptocurrencies enable machines to trade autonomously. In 2016 in the first phase of build, Bitcoin was the most well-known of the cryptocurrencies and there were numerous wallet applications available offering reasonable user experience that we could leverage for the study. (This was before speculative trading of Bitcoin caused extreme volatility.) The Bitbarista uses Bitcoin it gains to pay users for maintenance services. There is the potential that it could also be used to pay for coffee supplies, whose prices are also indicated in Bitcoin. The Bitbarista demonstrates its autonomy in three different ways: through analysing data and offering future supply of coffees in potential categories, through moderating the voting system and placing orders once coffee was about to run out, and finally by offering and delivering rewards for maintenance services.

Fig. 2. Left, shows Bitcoin payment being made with a mobile phone. Right, shows the Bitbarista offering a reward for emptying the coffee grinds

Voting categories: On the first screen Bitbarista shows the current coffee that is being served, the category in which this coffee ranked highest and how many previous customers voted for it (see Figure 3). On tapping the "Buy Coffee" option on this first page the Bitbarista moves to a screen where data that is purportedly from coffee producing countries scrolls by as the Bitbarista performs an analysis of existing suppliers. This data was mocked up by the research team and covers a range of potential data types from coffee producing countries that pertain to coffee production and price. From here the Bitbarista proceeds automatically to the next screen, which presents 4 options to vote for the next supply of coffee: "Best Quality", "Low Environmental Impact", "Best Social Responsibility" and "Best Price". In each category the price is indicated in Bitcoin and a particular coffee is displayed as "best match". Whilst the intention is that these matches are derived from the data on the previous page, there is in fact no relationship. The types of coffee shown in each

category, and the Bitcoin prices were updated manually by a researcher a number of times during the trial process.

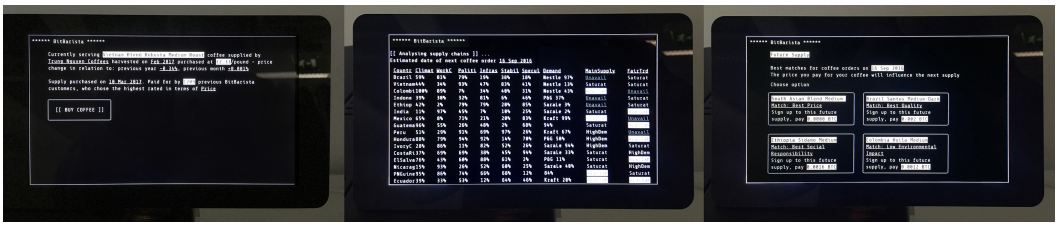

Fig. 3. Bitbarista interface, from left to right: first (or home) screen, data from coffee producing countries and 4 options to vote for future coffee supplies

A customer can choose one of these options to vote for the next supply and is then asked to pay the price in Bitcoin for their current purchase, which is most easily done with a Bitcoin wallet installed on a mobile phone (see Figure 2). Once the payment is received the Bitbarista serves the coffee and shows the current number of votes for each category. In this study, the Bitcoin wallet and payment process were fully operational.

Ordering new supplies: It is possible that the back-end for Bitbarista could be implemented using smart contracts, which would place the order for new supply of coffee directly with the grower. Revenues saved through disintermediation could then, for example, be used to pay higher prices for the coffee. In this study the way in which Bitbarista might use proceeds from its transactions was not suggested to the participants through the interface, in order that they could decide for themselves what might be or should be happening behind the scenes (in line with Odom and colleagues' description of research products, where customers construct their own idea of the future the artefact presents). In practice, to select and provide new coffees for the Bitbarista, researchers carried out a manual process of checking votes, physically buying the last coffee in the highest-ranking category and delivering it to the participant office. However, for the participants, the intention was this would appear to be handled autonomously by the Bitbarista. Coffee used in this study was purchased from a local vendor of artisanal coffees who sourced coffee direct from specific growers across various coffee producing countries.

Rewarding maintenance: Bitbarista offers a free coffee or small Bitcoin payment as a reward for tasks required for day to day use of the machine: filling the water tank, filling the hopper with beans and cleaning out the used coffee grounds. Sensors detect when a job needs to be done, and a request is displayed on the screen, describing the task and offering the reward (see Figure 2). When the job is complete Bitbarista offers either a free coffee with a vote for future supply, or a Bitcoin payout, which can be paid to a participant's Bitcoin wallet. To achieve this Bitbarista has a small camera to read the QR code generated by the wallet. By distributing part of its revenues to customers, Bitbarista would guarantee that small maintenance services would be carried out. This also suggests a way for money to circulate from machines back to people in potential distributed autonomous organisations.

4 STUDY PROCESS

In this section we move on to describe how the Bitbarista was used, and the protocols followed for the study and analysis. The Bitbarista was situated in three office spaces in the UK, for a period of one month in each. This time period meant that participants would regularly experience autonomous behaviours of the machine, vote for and receive new coffee supplies and have the

opportunity to perform maintenance tasks. Each deployment in the office was the same, with the analysis of results taking place after the final deployment. The selection of offices was based on a range of different organisational structures within the workplaces, and access to enough regular coffee drinkers with a range of technical abilities, who were keen to participate for the length of the trial. 13 participants officially took part in the study across the three offices, going through all phases of the study described below.

On the first day of the study the Bitbarista was delivered and set up in the office (see Figure 4). If participants did not have a Bitcoin wallet on their mobile phone, they were assisted in setting one up, and each participant was given approximately £30 worth of Bitcoin to cover the cost of buying coffee from the Bitbarista. They were given instructions on operating the machine, including on how to clean out the grounds, fill the water, and use the steamer to make cappuccino. They were not told what to expect from choosing a coffee and voting. Each participant was then asked to buy a coffee; which gave them an initial experience of using the Bitbarista and ensured their Bitcoin wallets were functioning correctly. A spare phone with a Bitcoin wallet was also left with the participants for the duration of the study, in case any of them had problems with their phone or Bitcoin wallet.

Following the set-up, each participant then took part in an initial interview lasting approximately 45 minutes. The purpose of this was to capture demographic information, learn about their coffee buying and consumption habits at work, and gather initial perceptions of the machine. The study of initial perceptions was a replication of the study carried out in 2016. During the course of the trial all interactions with the Bitbarista were recorded and logged in a data repository. This enabled researchers to monitor the interactions of the participants, check for potential problems, and keep track of the voting. A comment book was also left by the machine which also helped researchers to identify and address any problems arising on visits. Researchers would visit the office if problems arose, and to drop off new coffee supplies when required. During this time, casual conversations took place regarding Bitbarista usage and field notes were recorded. At the end of the 1-month period, researchers returned to collect the Bitbarista and conduct a final semi-structured interview with each participant, each interview lasting on average 40 minutes. Questions probed different aspects of using the machine, and interrogated participants on their behaviours and reactions. Conversation topics covered a number of different subjects, including but not limited to: perceptions of the initial screens and the 4 voting categories, experiences and thoughts on the voting process, experiences and reactions to performing maintenance tasks, thoughts on what Bitbarista might do with the Bitcoin, effects on thinking around the value and cost of coffee, and discussions with others in the office. Following this interview, participants were asked to draw a diagram representing how they imagined the world of Bitbarista, showing its connections and transactions with people, systems, other technologies and artefacts. Participants were then asked to describe these connections in another brief interview.

The first interview containing demographic data and basic information on coffee consumption habits was recorded directly into an Excel sheet and this was used to provide a picture of coffee consumption habits prior to the trial. The second part of this interview regarding initial reactions and the two final interviews were audio recorded and transcribed. Two researchers worked on the analysis process throughout and checked each other's work in an effort to remain reflexive of our own positions as researchers and interrogate how we were each interpreting the data. The analysis of the interview scripts began by looking at differences between the second part of the initial interview that explored initial perceptions and final interview scripts. The intention of repeating this interview of initial perceptions was that this would enable us to verify findings from the first study and see how these initial perceptions compared to longer-term use. On studying these scripts, it was apparent these closely reflected findings in the 2016 trial. We moved our focus onto the final

interview scripts. From an initial reading of these it was clear that participants experiences were distinctly individual, at first seeming to have few commonalities. In order to make sense of this, we adopted a more idiographic approach, by writing a profile for each participant which captured their individual behaviours, reactions and thinking about their experiences. These profiles provided us with a summary that helped us to see the distinctive features of the participants' behaviours and reactions, from which we could then more easily identify high level commonalities and contrasts across the participants' responses. We focussed this analysis on the reactions to the autonomy and thinking around the wider societal issues. In the following findings we then report under the subjects: rewarding the maintenance tasks, autonomy and the contribution to society, voting strategies and attention to provenance, and the effects on coffee drinking practices. We did not produce a formal analysis of the diagrams the participants drew for this paper, but they helped us to understand the participants' thinking, particularly with regard to how they imagined the Bitbarista worked and its role within society.

4.1 Participants

This section describes the results from the first interview and provides a view of the participants existing coffee drinking practices. These are interesting as we see later how use of the Bitbarista is compared to these existing practices. Practices differed across the offices, and were linked to the way in which the work connected the participants. All participants in this study were familiar with the Fairtrade certification, and although most of them were sceptical about this accreditation, uncertain whether it really upheld the values and practices it purports to, they said they would buy Fairtrade coffee when it was available.

4.1.1 Office 1: Participants P1, P2, P3 and P4. In the first office, participants worked for the same small start-up company, and shared tightly focussed, common goals. All four were male: P2 was aged 20-29 years, P3 30-39, and P1 and P4 40-49. P1 and P4 were in management positions and senior to P2 and P3. Participants had a high degree of technical literacy, with all four describing themselves as expert users of digital technologies. They all had prior knowledge of and interest in Bitcoin, with three of the four, P1, P2 and P4, having Bitcoin wallets on their phones before the study. They were all regular coffee drinkers, each consuming 3 or 4 cups a day, and described their reason for drinking coffee as needing a break from work or a boost.

Participants were located in one small office space. To access fresh water to refill the machine, clean the grounds or empty the drip tray, the participants needed to go to a kitchen space, at the end of another corridor. Previously, participants used a filter coffee machine to batch brew coffee for the team. Coffee was most often made by P1 who would also clean the machine when needed. Ground coffee was most often purchased in large bags from a local vendor by P4. Occasionally someone would pass a coffee shop on their way to the office, and send a message to the others to see if they wanted anything.

4.1.2 Office 2, Participants: P5, P6, P7, P8 and P9. This office housed part of the finance and administration team for a large organisation, with all the study participants working in administrative roles. They had overlapping goals and roles, although they tended to work independently, with one participant in the study new to the office. Four of the five participants were female. P8 was aged 20-29, P5 30-39, P6 and P7 40-49, and P9 50-59. These participants had limited awareness of more sophisticated or novel technologies and described themselves as dabblers in technology. None had a Bitcoin wallet on their phone prior to the study, or any prior experience with Bitcoin, although they had all heard of it. All were regular coffee drinkers, drinking around 3 or 4 cups a day, with the exception of P8 who regularly drank one coffee per day. They described regularly

drinking coffee in the mornings, and drinking it as part of social activity, or as part of a morning routine and to help with mental focus.

Four of the five participants were physically in the same room, with P5 in an annex room. The office had a small kitchen, in which the Bitbarista was located. Prior to the study these participants had their own separate routines for buying, making and consuming coffee, and did not share this process with each other. All participants except P8 bought ground coffee and made their own with a cafetiere as opposed to buying ready-made coffee, mostly for reasons of cost. P6 also bought ready-made coffees, but only from independent chains. P8 would buy ready-made coffee from chains such as Starbucks and made instant coffee which was bought via the organisations procurement process.

4.1.3 Office 3, Participants: P10, P11, P12 and P13. Office 3 was a co-working space housing a number of separate small companies, mostly individuals working freelance. Two of the participants were female and two were male. P11, P12 and P13 were aged 30-39, and P10 50-59. Within the office there was a degree of social interaction and collaboration, though they worked separately on individual projects. The overall technical literacy of these participants went beyond standard office tasks, as they used advanced software packages. Two of the participants described themselves as expert users of digital technology and two of them as dabblers. Participants all described themselves as regular coffee drinkers, but overall consumed fewer cups per day than in other offices, with two of the participants, P10 and P13 drinking one cup a day, and P11 and P12 drinking 2 or 3. P10 and P11 described coffee drinking as a social activity, while P12 and P13 said they used to improve performance.

This co-working space consisted of one large office, with a smaller meeting space at one end, and a small kitchen at the other. The Bitbarista was located in the meeting room, with water and facilities to clean the machine available in the kitchen. Prior to this study, P10, P11 and P12 bought ready-made coffee for themselves to bring in to work. P11 said that coffee was occasionally bought and made collectively, although not by her, but this was not mentioned by the other participants in the study. P13 bought ground coffee to make for himself.

Fig. 4. Setup in two of the participating offices

5 RESULTS

The second part of the first interview that replicated the study of initial perceptions in 2016 found similar results to this first study. The following results focus on the analysis of the final interviews

which explored participant behaviour and thinking around their experiences from the 1-month period in which Bitbarista was installed. The Bitbarista provoked a variety of responses, revealing different attitudes to technological systems and narratives of production and consumption. These are grouped under headings that capture the different aspects of the Bitbarista.

5.1 Heteromation: rewarding maintenance tasks

The majority of participants described a positive reaction to performing maintenance tasks and receiving a reward, although this was tempered by the time pressure of needing to get back to work. This enjoyment was especially evident the first few times this happened and participants reported feeling excited by the novelty: *"I was very, kind of like 'ooh!' when, when the water would run out [...] it's like 'oh, I get, I get to clean this one, that's nice'"* P5. Some participants enjoying being rewarded for doing the task and considered it a freebie: *"it was quite kind of 'ooh', you know when it said it needs to be emptied, 'great, free stuff!'"* P6; *"I enjoyed that, I like getting free stuff, I was happy to be rewarded that way"* P13; *"Even if it's just a little 'here you go thanks', it's quite, yeah, it's a nice thing"* P4. P4 also described how he was interested in the future prospects of this type of feature and speculated on how this could be developed for more complex maintenance tasks, which he would enjoy. However, participants also commented that having to perform maintenance tasks slowed down the whole process, and this was sometimes an issue for them as they felt time pressure at work. Even P6 who really enjoyed the Bitbarista said *"I was just, I just wanted my coffee, and get back to my desk, kind of thing"*. This suggests that once novelty has worn off, the maintenance tasks might become an irritant if they are not better integrated into normal everyday routines.

5.1.1 Value of the reward. A number of participants commented that getting rewarded for the maintenance tasks made the Bitbarista seem fair, and they felt that they were getting something back from the machine: *"it keeps it fairer, rather than a company just trying to suck as much money as it can from you"* P13. P1 in particular noted that as he had tended to make coffee and clean the machine in the prior coffee making routine, a reward for performing these tasks represented an improvement as it acknowledged his time and effort: *"it made me feel a bit better, because I was doing it for me and I was getting a better reward, rather, rather than doing it for no reward"* P1.

The Bitbarista offered a choice of reward: either a free coffee or a Bitcoin payment. Most participants considered which one was more valuable to them and stuck with their choice. It is important to note that the studies were carried out from March to November 2017, before the value of Bitcoin became a mainstream news story, and only a few participants were aware of how Bitcoin worked, its fluctuations and potential value. P1 always accepted payment over free coffee, because he noticed that the Bitcoin payment was worth roughly 2 coffees. P6 described how he would always accept payment, because from previous experience he suspected the value of the financial reward would be more than goods. However, the majority of participants most often accepted the free coffee, and considered this more desirable because they were already at the machine in need of a coffee and this was the quickest route to getting that, being paid in coffee was more *"immediately gratifying"* P7.

For some, the process didn't seem worth the reward, particularly when they weren't accustomed to doing these tasks. In Office 1, for example, P1 used to make coffee for everyone and the arrival of the machine disrupted this order. Further, Bitbarista would request maintenance tasks to be performed when it needed them, which would add to time spent at the coffee machine. P3 described the this as off-putting because it meant that getting his coffee would take longer: *"'cause it's quite annoying if you're going to get a coffee and then it goes 'oh, you've got to do all this before you can get a coffee'. Maybe it could just advertise, uh, if it had a bit more foresight as to when it was running out"* P3. P4 also described how performing these tasks was quite onerous and felt they had sufficient

leadership in the office to organise jobs getting done without a system of reward - he would do it himself or tell someone else to do it. Rather, P4 suggested Bitbarista would be more beneficial in a space used by a number of different businesses, where there is no consensus about whose job it was to perform maintenance tasks, and so the autonomous, third-party mediation of this activity would be useful.

Some participants were not concerned at all with the reward because they would do the maintenance tasks anyway. P9 described doing the tasks for free as part of being in a community: *"you would have to kind of stick with your principles, and I think being part of this maintenance and, and, and, and troubleshooting is probably part of it. It's a sort of a certain commitment that you make"* P9. P11 describes how these chores need to be done anyway, and that the small micropayment didn't really make much difference: *"I wasn't actually, in the end, so keen on getting the Bitcoin for it, it didn't really matter to me, 'cause that is what I was doing anyway"* P11.

Whilst in some cases the financial reward was well received, in most cases this payment was considered too small and seemed either trivial, or unnecessary, and for some devalued the contribution that they felt they were making to the community. The free coffee was better received, as the process was faster and this trade - maintenance for coffee - seemed more in keeping with the ethos of the machine.

5.1.2 Practical aspects of rewarding maintenance tasks. The process of financial rewards in the Bitbarista was not consistent across all tasks. The machine had one necessary task - emptying the drip tray - that it did not alert customers to or offer a reward for. This was difficult to build into the design because the coffee machine from which Bitbarista was built had no sensors to detect when the drip tray was full. During the trial researchers noticed on visits that the drip tray was often full, and when asked participants commented that it was often left until it was overflowing. P6 described how she had eventually emptied and cleaned the drip tray a number of times, and said that she suspected it was left like this because participants were waiting for the Bitbarista to offer a reward for completing this task. This also points to the potential undermining of community practice by commodification.

In contrast to this, some participants viewed the Bitbarista as necessarily located within a community. When discussing other potential contexts for Bitbarista, participants expressed reservations about allowing public access. P9 and P5 in particular reported that they would not necessarily trust people who are not invested in it to do the maintenance tasks properly. Others thought that the sense of community was important for appropriate coffee choices to be made: *"Because they're people who'll be there in future, drinking the coffee that they vote for"* P7. This suggests that even though the current model of heteromation appeared to undermine altruistic behaviours, that participants nonetheless saw the Bitbarista as operating within a community context.

5.2 Autonomy, disintermediation and contribution to society

Participants tended to place the Bitbarista in the context of prevalent, contemporary narratives around coffee production, consumption and pricing. Understanding of the machine's potential autonomy was mixed. While half the participants could see Bitbarista as a completely autonomous system, sometimes ordering coffee from a cooperative but still connecting with farmers directly, the other half (P6, P7, P9, P10, P11, P12) envisioned a distributor or agent mediating orders, suppliers, and payments.

The interviews and diagrams revealed a range of views on the value of Bitbarista's autonomy. P3 believed that the Bitbarista would be cost-neutral and so the main benefit would be to reduce overall costs for consumers. Several participants wondered where profit would go, with most of these participants believing that a percentage would or should go to charity. P11 speculated that

the way in which Bitbarista selects top matches could create new problems for growers who are competing to optimise their position in the categories. In order to ameliorate this, she suggested Bitbarista should pay into a fund that would pay out regular dividends to all participating farmers. P11 draws this in her diagram, which shows an example of the complex possible worlds participants imagined in relation to the Bitbarista (see Figure 5).

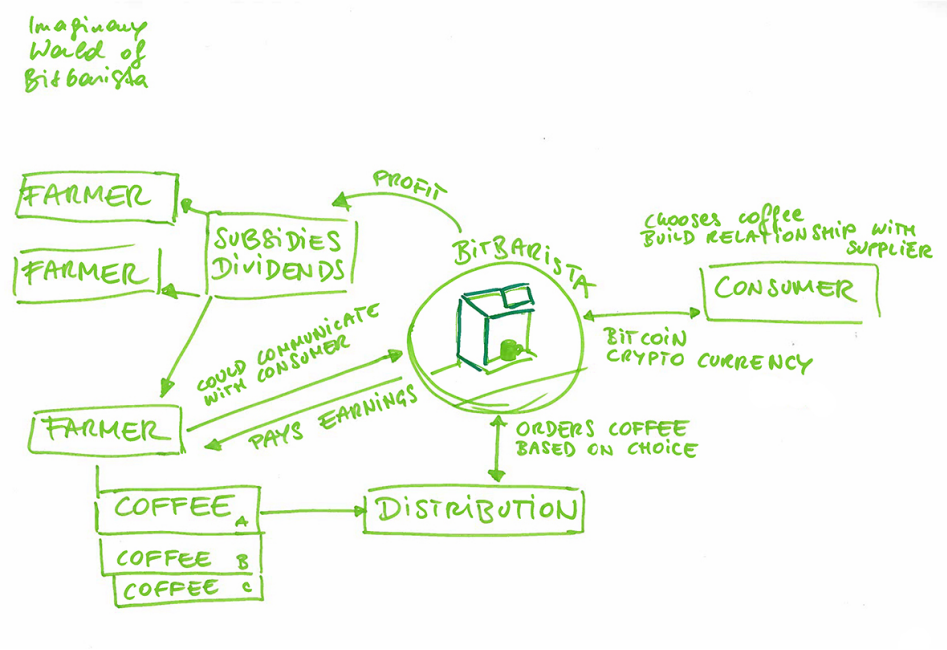

Fig. 5. P11 diagram of her imagined world of the Bitbarista, showing Bitbarista paying out dividends to all participating farmers

P6 also suggested the need for a mechanism whereby Bitbarista would pay something back into society. She viewed this as a necessity, given that it was replacing a salaried human being who would have routinely performed those tasks as part of their job: *"because you don't have the people running costs, you're not actually paying somebody's wages, or there's less people, you're not actually having to pay a barista's wages [...] so if you're making money off this thing, please give some of it back into society rather than it all going back into your own pocket"*. P6 goes on to describe how this produces a value to her: *"if it was like, you know, 'Bitbarista has made this much profit and we've donated this much to this cause this month', again, that would give you a warm fuzzy feeling"*. P4 describes how a percentage of the proceeds could go to charity and this would motivate use of the machine: *"the commons, can, can look after [...] and if so, can you then move on to new stuff like, um, it, um, gives, 2% of the proceeds go straight to charity or something, so there's, there's an element of, um, uh, like the Fairtrade thing was [...] people will actually use this resource because a percentage of its proceeds [...] are actually performing some other, uh, purpose"*.

Whilst the use of Bitcoin for payment was not a central focus of the study, rather one of the props, we explored current knowledge and attitudes to it during the trial. Most participants struggled with understanding what the value might be in small fractions of Bitcoin. This made it onerous to compare prices of the different voting options, and they attempted to understand its value by translating the value into pounds sterling, their home fiat currency in the UK. Some participants

understood the concept of Bitcoin as a global currency, potentially crossing the boundaries between separate economies, forming a direct payment between consumer and grower. P9 talked about the vision of a universal currency, which she associated with Bitcoin: *"Well, I think it's, there's less, less barriers, because of, you know, mobility, I guess, and whether you're here in Edinburgh or in London or in Paris, you know, it would all be the same [...] the value of a coffee [...] would be X amount of whatever the currency, if you can call it currency [...] You would, you would imagine it would be more stable in a relationship between Britain and France"*. Others described the evident and severe fluctuations of its value in relation to fiat currency (that began to occur before the end of this trial period) as a potential barrier to its use for business such as this. P6 wondered how this would work in reality if she was operating with two currencies, being paid in pounds sterling, and then buying in volatile Bitcoin. This would make budgeting for coffee consumption difficult. P12 expressed concern about Bitcoin potentially losing value in relation to local fiat currency: *"you could have a business one night and the next day it's crashed"*, and how the lack of current regulation and security could make it an easy target for hackers.

5.2.1 Rewarding maintenance tasks: in summary. Participants has a clear sense of what they considered fair, and that the Bitbarista's autonomous behaviours should conform to notions of fairness. Whilst the use of Bitcoin was considered positive where it might help to pay growers directly and fairly, participants had concerns around their own ability to manage this in the context of their use of local currency.

5.3 Introducing provenance: long term and short term thinking

In the design of the Bitbarista we have developed an autonomous system that also brings provenance data into the process of consumption. Participants witnessed the process of Bitbarista analysing provenance data and producing 4 choices of potential future supply. In this section we explore participant responses to the analysis process and the 4 choices the Bitbarista presents for future supply.

After a customer has selected "buy coffee", on the first screen, the Bitbarista presented a screen with data on different attributes of coffee suppliers in the format of a simple table. The intention was that the Bitbarista should show its analysis of data from coffee producing countries, and select the top-ranking coffees in four options (Best Quality, Low Environmental Impact, Best Social responsibility, and Best Price) on the following screen. This information was displayed for 7 - 10 seconds. Reactions to this process were varied. P4, P7 and P13 reported some degree of annoyance as this information slowed down the process of getting a coffee: *"no, I didn't really notice [the data presented], and we've been really busy, so you, you're just kind of like 'give me caffeine"'* P7; *"I think it was tunnel vision, just wanting to, just more in the short term, I just wanted coffee"* P13. Other participants expressed an interest in the data: *"you go 'actually, that coffee's coming from Nestle, right, so I'm going to avoid that"'* P5, and described how it triggered thoughts about how this process was done: *"it made me wonder, like, you know, how, you know, what, how is BitBarista purportedly, um, assessing, you know, the, the social responsibility?"* P5. Some participants commented that the information went by too quickly: *"the quick stuff that goes up there, and it's like, where it was, seemed to be retrieving data about, um, whether or not it, which coffee's going to be the most socially responsible"* P5. Some reported that they just didn't look at the data as it didn't seem to be for them: *"I didn't have the sense that it would mean anything to me, that data, particularly"* P7. Whilst this data was intended to look machine produced, for P9 the presentation was too technical and she considered that a story on coffee growers would make it more interesting. P8 thought that the presentation looked like an internal process of the machine: *"it seemed like it was just doing something to get to the next stage"*. Reactions to the speed of presentation suggest that this

may be better tailored to specific contexts, and enable people to either skip viewing this process, or interrogate the data themselves when they want to understand the system's processes better. Furthermore, whilst the design of the screens was intended to give the appearance of a machine-like objectivity, it could be adapted to encourage more engagement and exploration.

5.3.1 Voting strategies. The following screen invites the participants to consider the four categories, and vote for their relative importance in subsequent coffee supplies. Despite the pressures of the work environment most participants went to considerable lengths to create a rationale for their choices. For example, P6 described reasons for selecting the low environmental impact option: *"in my idealistic head I would hope that people would realise, if you're going to be socially responsible if you're producing something, you've also got to be environmentally responsible, because you live in the environment"*. However, as time progressed participants tended to choose a voting strategy and stick to it throughout the period. For example, P9 considered quality different for everyone, and that social responsibility was too vague a concept. She then reflected on the consequences of her actions in the long term and decided to opt for environmental impact: *"because if the environment gets worse then we will have to pay the price"* P9. She stuck with that choice throughout the study. P2 described how the quality of his coffee was paramount, and other issues did not come into it. P4 demonstrated some cynicism around the ethical voting options, which he related to the narrative of feeling good about oneself having paid more for organic produce. P13 initially made a choice of the coffee ranked highest at that time, based on the country of origin, and then remained consistent: *"so I really just guessed, to be honest, Guatemala looks nice, top left [...] and then that just became an instinct, the same each time"*. When asked if he noticed when this coffee changed under the vote option, he said he did not. Furthermore, the repeated offer of different choices was sometimes considered an irritant. P3 explained that he would be consistent in his beliefs and wouldn't go for another option: *"then you're not going to spread your votes around [...] I think the value of having multiple votes is not really, it's more of an inconvenience"* P3. P5 described feeling that he had made a once-and-for-all decision at the start, but then changed his choice as the study progressed. Some participants (P7 and P11) varied their votes between two choices in order to spread their votes fairly.

5.3.2 Ethical options and binary choices. Four (P5, P6, P7 and P11) participants described difficulty of choosing between two "ethical" options and tended to alternate between them: *"I tried to roughly kind of be voting in equal amounts"* P7; *"it felt difficult to make a choice between those two so I always alternated [...] I do one time this and one time that and that balances out"* P11. P5, P6 and P9 acknowledged that one was generally more important than the other *"I would probably go for environmental responsibility, 'cause the environment's going to last longer than people"* P6. P1, P6 and P11 also wondered why these were mutually exclusive, P11, *"'lower environmental impact' and 'best social responsibility', those were usually the ones that I, um, chose between, and I always felt, why is it a binary choice, why couldn't there be one that maybe combines it in some way?"* P5. P5 described how he started voting for the socially responsible option because the highest ranked coffee in this category was from a grower called "The Lopez Family", and liked the idea of helping an individual family. When the coffee in this category changed, he began to sometimes choose environmental impact, and described how, if he had had poor interaction with people that day, he tended to choose environment over social responsibility.

Although best price and best quality options were largely disregarded by most participants. P6 and P11 described how they experimented with voting for best price and quality options, but reported not feeling good about this choice: *"'best quality' is more expensive, and, and less groovy [laughter] so I guess for me personally, I was like, it's not one I would pick most of the time, 'cause, you know, I don't, I don't, I don't want to put luxury over social or environmental responsibility"* P6. Guilt

was a recurrent sentiment in this case: *"I also sometimes felt guilty for picking the cheap option, with low-cost option, as opposed to one of the, the two, um, um, sustainable, socially responsible, um, feeling that I ought to be always picking those two"* P10. Only P2, P4 and P13 did not consider ethical issues while deciding how to vote, and whilst they acknowledged that they were concerned about ethics in general, this was not important to them when consuming coffee generally, or in this study.

5.3.3 Individual versus collective vote. In addition to considering their own votes and the consequences of these, some participants were also interested in the voting of others. Bitbarista displays the results of all the voting so far when it is serving coffee. So whilst participants cannot see how other individuals are voting, they have a sense of what others are voting for collectively. This was the subject of curiosity and some discussion *"Do you actually know who is voting for what in your interface? Can you see what I'm voting for and what the other users are voting for?"* P11. P1 and P11 wondered if their choices could be monitored and were concerned about how others might perceive them. For example, assuming that the Bitbarista could identify him, P1 was concerned that having voted for less ethical choices on behalf of colleagues would affect his profile: *"It would be interesting to see what I selected, I pretty much always selected the ethical one [...] but not, um, because I paid for a few others, so it might not show up in the data"*.

P1, P6 and P11 who all voted for perceived ethical choices were concerned about the number of votes for less ethical choices, and reported that they would want to discuss this with their colleagues, if they knew their identities. P7 described how seeing her colleagues voting in a similar way made her feel more connected to the office: *"it was sort of nice that we were voting in a broadly similar way. There was only one or two people who were sort of less ethical ones, only one who was 'give me cheap coffee'"*. Overall, where ethical beliefs were present, there was a sense of desire that the vote of colleagues would be aligned with their own beliefs. P5 reported considering the overall votes, and that there was no point in voting for an option that wouldn't win: *"I think, turned into a voting war between, um, the environmental and the social responsibility factors, and people have stopped voting for the other two."* P5 also suggested that voting for best quality and paying for this might have been problematic if everyone else was voting for the cheapest one.

5.3.4 Provenance: in summary. Participants gave the voting considerable thought initially, and the interviews showed that it was important to most participants that the general vote reflected their own values. However, despite this apparent investment in the voting process we found that none of the participants noticed or verified that the coffee delivered was the one that had received the most votes, despite this being visible on the label of the newly delivered bags of coffee and the details of the current coffee served being continuously displayed on the home screen. This may in part be a result of interface design choices, where fonts and screen layout were intended to suggest objectivity by appearing less like a graphical user interface and more like machine code (through use of the Share Tech Mono font and limited hierarchical structure, See Figure 3). However, this meant that changes to the home screen were not visually apparent, and it is likely that participants failed to notice them when updates were made. Furthermore, the coffee packaging was similar on all coffees with the provenance information not explicitly promoted. We also suggest that while participants were required to consider issues of provenance in future supplies at the time of purchase, for most the actual coffee served was not so important in the moment. Most participants reported that they were not discerning coffee drinkers and commented that they found the coffee served was of consistently good quality, which was their main concern regarding coffee at the time of drinking. As such they may not have felt the need to check the coffee packaging, being happy with the taste, and taking the delivery of the correct coffee on trust.

Participants also questioned the binary, reductive nature of the choices presented, and this potentially points to a need for either simpler options that encompass more qualities (e.g. an

"ethical" vote to cover both environmental and social concerns), or conversely the availability of fined-grained voting options that break down aspects of the categories into more detail. Due to time pressure in the workplace, participants developed strategies to reduce time spent on this activity. This suggests that activities requiring thought around provenance of goods at work need to take place at times that do not disrupt work activities, for example at lunchbreaks.

5.4 Creating change: coffee drinking practices and office dynamics

Whether participants had previously batch-brewed communal coffee, as in Office 1, or brought in ready-made coffees from the outside as in Office 3, the Bitbarista forced participants to do things differently. In Office 1, participants had to switch from collaborative batch brewing to individual purchase, and all participants were required to perform maintenance tasks as part of normal use. However, P1 continued to perform most of the maintenance tasks for the Bitbarista, including changing the water after the weekend and often cleaning out the grounds and emptying the drip tray. P1 welcomed the Bitcoin rewards for the maintenance tasks, feeling that his efforts were acknowledged. P2, P3 and P4 saw the new effort and time required to use the Bitbarista, including voting, purchase and maintenance, as hurdles, and they quickly devised strategies to cope with extra demands. P2 and P3 commented that did not enjoy the autonomous features as they took too long, and they preferred the convenience of batch brewed coffee.

In Office 2, prior to the study, 4 out of 5 participants most often made their own coffee in the kitchen. These participants found ways to adapt to the new practice of using Bitbarista, to make the most of what it offered, and still get the coffee they wanted. These adaptations quickly formed into new coffee making routines. For example, P6 had long-standing problem with the Bitcoin wallet on her phone, she was not able to make two consecutive transactions, but wanted two shots of coffee. She found a way to adapt by using the phone with the spare wallet for her second Bitcoin transaction. This became her routine. P5 made filter coffee in the way he used to prior to the study and augmented this with a shot from the Bitbarista: *"I start the kettle for my normal cup of coffee, and then I access the Bitbarista, and while I, you know, I sort of got used to... doing, having this kind of five minutes a couple of times a day with my, do Bitbarista stuff [...] it's easily become part of my ritual"*. However, P5 also said that he would return to his normal routine now the Bitbarista had gone. This office had the highest overall consumption of coffee from the Bitbarista (after adjusting for the extra participant); it was popular with participants, who commented that they would be sad to see it go. In this office participants were working in similar roles for the same organisation, and although their coffee making habits remained separate, they described how the Bitbarista provided a talking point and created a sense of cohesion, sometimes discussing the voting, or assisting each other with technical problems with the Bitbarista or their Bitcoin wallets. It was acknowledged across the group that they were spending more time making coffee and discussing the progress of the voting: *"it sort of our, uh, line manager's been a little bit like [making faces] <laughter> 'cause sometimes we'd spend a little bit long kind of trying to figure it out, sort of thing"* P7.

In Office 3, participants are involved in entirely separate working practices, and the presence of the Bitbarista did not appear to increase interactions. P11 and P13 reported there was little or no discussion of the Bitbarista, P13 and P10 say they discussed it, but they were sitting at adjacent desks so this may have made it easier. In this office the overall consumption of coffee from the Bitbarista was lowest. P12 commented that the speed of interaction was an issue, compared with how quick and easy it is to buy a readymade coffee from the outside. Participants in this office seems to lack awareness of others' experiences of the Bitbarista. For example, P11 was very conscientious about caring for the machine and concerned that the voting should be ethical, but completely unaware of how others were voting, and didn't discuss this with them during the study. P13 considered

the system particularly positive for large offices where people would then be able to avoid coffee rounds - where one person makes coffee for a number of people.

5.4.1 Creating change: in summary. In Office 1, even though new practical behaviours were developed to cope with the demands of the machine, pre-existing roles regarding coffee consumption practices were maintained. In Office 2 participants described the benefits of the Bitbarista as a talking point, enhancing the sense of community within the office, and helping to integrate a new member of staff. In this office participants constructed new coffee making routines in order to get the type of coffee they were accustomed to. In Office 3 participants worked as individual and separate businesses, and communication between them and awareness of others' behaviour was limited.

Whilst the Bitbarista caused participants to adopt different practices around coffee drinking, it did not affect the office dynamics, with individuals in the different offices maintaining their usual roles in practices as far as possible. Like any technical system, its use was shaped by its social context. That the Bitbarista was received differently in each of the office contexts suggests the need for tailoring potential interactions to different contexts. It is possible that differing sets of smart contracts could underpin versions of the Bitbarista, for example one that facilitates cooperative practices rewarding maintenance tasks with community-based recognition, and another designed for individual use where links between potential customers and collective practices of customers are limited. These may then fit better with existing dynamics and practices.

6 DISCUSSION

6.1 Rewarding but also commodifying maintenance

Rewards offered by Bitbarista were mostly welcomed by participants, serving as a motivator for those who would not normally do the chores, or simply as a reward for those who would do the chores anyway. However, much of the initial excitement around the rewards was based on novelty; in time, participants either included the maintenance tasks in their routine, or did not. The time required to do a chore when a participant really wanted a coffee was an issue which the payment did not influence to a significant degree. Whilst in some systems, such as Amazon Turk, participants can choose tasks they wish to assist with, with the Bitbarista the presentation of the task occurs at arbitrary times. This can prevent people from planning chores and integrating them into their routines. It also delays coffee making, which is perceived as inconvenient.

The machine required maintenance tasks to be carried out by whoever approached the machine when a task was required, which should in theory make the distribution of these tasks fairer. In practice, however, the presence of the machine did not necessarily change who would carry out these tasks. In a context where the participants' roles in coffee making were previously well defined, the non-hierarchical dynamic proposed by the Bitbarista risked undermining those previous structures, which were generated out of cooperation and goodwill.

As previously described, trust in autonomous systems is guaranteed by payments automated via smart contracts. Distributed autonomous systems rely on micropayments to guarantee particular interactions with different actors. This study however revealed that the rewards discouraged or de-valued other forms of contribution based on communal participation, altruism or simple habit. The payment increased the number of helpers, but decreased opportunities for people to contribute a service to the group by doing the chores voluntarily. Similar results were presented by Carroll and Bellotti, who explore the difference between bartering and monetary systems of exchange. They explain how money, whilst simplifying the process of exchange by providing a universal indicator of value also, "reduces the need for trading partners to create and strengthen particular social ties and trust relationships". Money promotes individual rather than community focussed

thinking and action [6]. Similarly, what we have found in this study suggests that existing values of community responsibility could potentially be jeopardised by systems of financial reward. A number of other initiatives, like Bitbarista, attempt to use local or cryptocurrencies to facilitate community exchange and disintermediation, in order to increase participation [16]. However, the process of commodifying these community activities and initiatives by bringing a financially focussed mindset to the task may in some cases break the very behaviours that they seek to support. We see this as a potential consideration for the process of heteromation in autonomous systems, where machines outsource physical tasks to humans and incentivise this with financial payments [12].

6.2 Tensions between short and long term thinking

Bitbarista presents a model of consumption in which the price paid for a coffee is based on the customer's choice of future coffee supply. Participants were prompted to consider the future consequences of their transactions in two main ways. Firstly, they had to consider how their vote would impact their costs and the next supply of coffee for the office (e.g. voting for more expensive choices would be inefficient if there were more votes for cheaper ones). Secondly, they had to weigh the consequences of their choices in broader terms. Both the "Environmental Impact" and the "Social Responsibility" options triggered thinking around the possible future effects of voting or not voting for these options. Participants had to consider how their choice might affect: the coffee growers; the consequences for social practices in the country of origin; the impact on the environment; the way they feel about themselves as a result of making this choice; and the way others might perceive them. Participants in this study were all familiar with the concept of Fairtrade. However, they would not normally think about these choices every time they made a coffee for themselves at work. They also noted that in coffee shops, this information was very rarely available, certainly not to the extent to which it was presented on Bitbarista.

These thought processes created a cognitive demand on the participants, whilst they were trying to achieve the short-term goal of making a coffee at work. It brought into play a separate set of thought processes around the attention required by the interface, the need for a break from work, and the necessity of getting back to their desk. The clash of these two types of thinking generated conflict for some participants who, as a result, adopted a strategy of repeat voting, rather than considering the possibilities each time. This created a coherence of thinking while speeding up the process of getting the coffee. The same was true when it came to choosing a free coffee or Bitcoin payment as a reward.

Presenting information about provenance at the time of purchase clearly engendered conflicting types of thinking. In line with the work of psychologists [18] we see this as a tension between different modes of thought: considering the long-term consequences of actions requires analytical skills, while immediate practical considerations require instantaneous responses. Thinking about issues such as sustainability and social impact conflicted with the need for a quick coffee. This led to a sense of guilt for not doing enough for the environment, or fulfilling a social role, or to a disbelief in the potential impact of their actions. Even when reflection on provenance was initially welcomed [33], the repetition of information over time became more disruptive than informative, and was perceived as simply slowing participants down.

The main challenge in presenting data on provenance is to situate the display of information in such a way that it is seen without being disruptive of the lives and routines of consumers. This means nudging people to access information and revealing machine decisions rooted in the data, while at the same time balancing repetition of information and perceived time usage. It is necessary to recognise the conflict that arises when the immediate response to the need for coffee is slowed down, to create a space for reflection. Separating information display and consumption stages to

present information when time is less of an issue, or tactically displaying the information while customers wait for coffee to be poured may be less disruptive.

We consider that the Bitbarista's interface could be reconfigured in three ways. Firstly, the repetition of information could be reduced by (a) allowing participants to skip initial stages of data display, or (b) stressing variations in the information displayed in the data overview, so as to retain attention of those who have already seen it, or (c) permitting participants access to more details when purchase options are presented. Secondly, the system could allow participants to set options according to their individual workplace, revisiting and updating them when convenient. Thirdly, and perhaps more significantly, it could incorporate routines for regular reflection, e.g. only presenting the information in the morning or at lunch time, when longer breaks could be available.

6.3 Autonomous systems and provenance

In this study, we have expanded on work that explores the use of technology to explore the potential value of product provenance, by examining everyday interactions around an autonomous system that delivers provenance information. In doing so, we have identified four main challenges.

The first challenge, as mentioned above, relates to the ability to guarantee that maintenance tasks will be carried out without commodifying all interactions with the machine (which is the primary aim in commodification in DAOs, such as in the Fairbike project [24]). We observed that while rewards were initially welcome, largely because of the novelty, they tended to discourage routine care and selfless contributions. This raises the question of how groups develop a sense of responsibility for shared goods when this responsibility is mediated by machines. There is a danger that commodified interactions become naturalised. If every action is recorded and feelings of obligation and trust are moderated by digital ledgers, nuanced negotiations be discouraged, and it may be harder to develop judgement of situations and relationships. This could ultimately discourage learning on how to take responsibility for communal goods and possibly actions towards the group.

The second challenge relates to giving people the opportunity to assist rather than making them respond to the needs of the machine in an ad-hoc way. There is a sense of powerlessness in having to react to the demands of machine at random times, particularly when participants were keen to have a coffee, and this expectation was not met. Transferring the responsibility of maintenance issues to humans, also means transferring to them the power to decide when to perform these tasks. The seemingly random timing of maintenance demands fosters instability, which may ultimately compromise the creation of the space necessary for reflective thinking about coffee consumption. The design could be better tailored to enable customers to perform these tasks in a way that fits into their schedules.

The third challenge relates to the ability to communicate information where the action matters. As mentioned above, we identified that displaying information on provenance at the time of purchase may be welcomed initially, but immediate needs and a feeling of time pressure curbed reflection. The display of information became more disruptive than informative, with participants looking for avoidance strategies, to minimise the time this took in future transactions.

The final challenge is to ensure that ethical considerations are not cast aside as autonomous systems become increasingly ubiquitous in society. The model of self-service could not only remove social interactions but also reduce the number of jobs, either because people are buying coffee from a vending machine rather than a person, or because they are not making batch coffees for others in their workplace, or buying coffee for colleagues. The loss of such cooperative practices would be regrettable.

Commodified interactions offered by autonomous systems can create value in an ad-hoc way. Such systems create an opportunity for individual ethical choices by offering independence from intermediaries such as governments, lawyers, and other organisations that may be seen as controlling these systems for other purposes. An absence of these intermediaries tends to be seen as creating a trustable transparency, which is in some way aligned with pre-determined ethical values. However, commodifying interaction with these systems can hinder active engagement in these ethical choices. If a machine, such as the Bitbarista, makes micropayments to individuals rather than employing a member of staff, then it may not be perceived as making a positive contribution to society.

7 CONCLUSION

We designed, built and implemented Bitbarista based on latest available technology with the aim of contributing to a timely discussion on autonomous systems, particularly given the ability of recent technologies and radical concepts such as distributed autonomous organisations, which aim to bring new objectivity and fairness through disintermediation and transparency. This study focussed on responses to the machine's autonomous behaviours in the wild, both in its presentation of choices and mediation of voting, but also in the incentivisation of its maintenance tasks in a process of heteromation.

The study had limitations. Most participants had to install a Bitcoin wallet on their phones and were not previously familiar with them (although three of four participants in Office 1 did have Bitcoin wallets), though this did not appear to affect the results. Participants were also given Bitcoin to use during the study instead of using their own money, which may have affected their choices in terms of cost. The data and voting categories could have been presented in a different way, for example enabling participants to interrogate the data, or providing finer-grained categories to vote for. Overall however the study brought valuable insights into reactions to such autonomous systems, and how they mediate decision making and practices in office environments. We draw three main conclusions to consider when introducing data on provenance into everyday autonomous systems:

Minimise commodification of interactions While the machine revealed the potential of autonomous systems to promote discussion and support conviviality, it also disrupted existing systems of collaboration. This was particularly noted when it translated what had been communal tasks or interactions, such as maintenance, into commodified transactions. Minimising the use of monetary rewards would give space for people to create their own systems of collaboration and exchange which are not financially based. Future work should explore other means of reward, e.g. by translating actions into charitable donations or to support the development of local projects.

Increase information on the state of the machine The machine was designed to prompt participants to undertake maintenance services as and when required, without advance warning. This created tension, either in the sense of slowing down the coffee purchase or in creating an expectation of gaining something from the system. The lack of predictability meant that participants could not plan or organise maintenance, either individually or within the group, or create habitual practices to fit in with their work routines. Improving the predictability of maintenance requirements would therefore empower consumers to organise maintenance, rather than being in thrall to the machine.

Situate information in time and into people's routines Getting a cup of coffee in the workplace is an event that usually requires only short-term thinking around the practicalities. The introduction of a process which demanded long-term thinking about provenance, environment, value etc., demanded a different kind of cognitive input. At first this information was welcomed but with time and repetition, some participants found it irritating, and tried to reduce the cognitive load by strategising, prioritising individual considerations rather than reflecting on the wider

concerns. Clearly designs intended to become part of everyday practices need to take account of this tension, and consider carefully the positioning of the information display within people's routines, preferably creating predictable times for accessing this information. Furthermore, we observed that the machine had a varied impact within different office social structures, suggesting that such systems may need subtle adaptation according to the particular contexts of use.

8 FINAL REMARKS

Blockchains, smart contracts and distributed autonomous organisations have given rise to abstract notions of new social systems. These systems bring a new type of automation, shifting power structures, enabling disintermediation and trust in provenance data, and promise great potential to change the way we interact and think about the world. However, considering how new technologies affect the micro exchanges comprising our everyday lives is equally as important. Design has a key role in revealing the possible impact on moment to moment practices and thinking, providing essential insights into not only the way they may fit into, or disrupt, daily living, but also indicating potential implications for wider social structures and values. Here, the design of Bitbarista has shed light on implications of incorporating provenance data into an autonomous system, pointing to considerations of how this could be achieved in more effective ways.

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